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FUTURE DIRECTIONS FOR ASTRONOMICAL IMAGE DISPLAY

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Annual Report

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Principal Investigator
Eric Mandel

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Smithsonian Institution
Astrophysical Observatory
Cambridge, Massachusetts 02138

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The NASA Technical Officer for this grant is Joe Brederkamp, Code 077.0, NASA Headquarters, Washington, DC 20546-0001.

1 Project Objectives

In our "Future Directions for Astronomical Image Display" project, the Smithsonian Astrophysical Observatory (SAO) and the National Optical Astronomy Observatories (NOAO) will evolve our existing image display software into a fully extensible, cross-platform image display server that can run stand-alone or be integrated seamlessly into astronomical analysis systems. We will build a Plug-in Image Extension (PIE) server for astronomy, consisting of a modular image display engine that can be customized using "plug-in" technology. We will create plug-ins that reproduce all the current functionality of SAOtng. We also will devise a messaging system and a set of distributed, shared data objects to support integrating the PIE server into astronomical analysis systems. Finally, we will migrate our PIE server, plug-ins, and messaging software from Unix and the X Window System to a platform-independent architecture that utilizes cross-platform technology such as Tcl/Tk or Java.

2 Activity for This Reporting Period

The PIE server will build on and also will replace the widely-used SAOtng image display program (as well as related programs in the SAO R&D software suite). We intend to replace components of SAOtng with new PIE server components in a series of progressive releases. (This follows the paradigm of George Washington's axe, which, according to legend, has been in continuous use for 200 years: the handle and the head are replaced alternately.) Therefore, at SAO our first major effort of the year was to release a version of SAOtng that would satisfy current user enhancement requests, fix known bugs, and place the program on a stable footing while we design and replace the first set of components. Toward this end, we worked throughout the spring of 1997 to produce release 1.7 of the SAO R&D software suite. A public release of 1.7 was made on 1 July 1997. Major improvements included support for private colormaps, auto-configuration of frames, auto-flip of images, generalized region name/color associations, marker-specific analysis, improved printing options, and many GUI improvements.

Response to this release has been positive and steady, with a user retrieval rate that is higher than for previous releases. In the first four months of availability, more than 350 unique sites have retrieved the software, either as source code or in one of our binary distributions (SunOS, Sun Solaris, Dec Alpha, SGI, HP, and Linux). We made a minor adjustment to the release (version 1.7.1) on 1 September 1997 to fix a few bugs (mostly concerning data conversion on little-endian computers) and to add some support for deep frame buffers. In doing this, we have placed ourselves in a position to work on the PIE server while providing excellent support for current users.

At NOAO, we began the year with an intensive effort to research message bus technology. We studied and evaluated several message bus systems and related technologies (CORBA, OLE, KoalaTalk, ToolTalk, PVM, as well as several home-grown astronomical systems). Based on this evaluation, we chose PVM to serve as the initial underlying trans-

port layer for the message bus. Although PVM is not a general message bus with the desired producer/consumer event capabilities, it does offer many important features such as heterogeneous platform support, broadcasting, message routing, data conversion, and task scheduling. It also is relatively lightweight, well-supported, and free from licensing restrictions.

An initial draft design for an astronomical message bus was developed and circulated for comment. A draft description also was produced of the Distributed Shared Object (DSO) technology that will be used to implement services on the message bus. In particular, we envision that the image display "frame buffer" will be a distributed shared image object (DSIM) implemented using the DSO technology.

Concurrent with design specification, we developed prototype implementations of the message bus (using PVM) and a DSIM. These working prototypes now are in use in the NOAO Mosaic Data System. They reflect the evolving specification and at the same time they are being used to elucidate important design and implementation issues with respect to message bus technology.

At SAO, message bus technology also was investigated, but from the point of view of "minimal buy-in". This concept of hiding from users and developers the complexity of inherently complex software has become critically important in the astronomical community: high buy-in is a major barrier to software sharing. However, because hiding software complexity makes software more difficult to implement, we are keeping this effort separate from the effort of designing and prototyping the full-function message bus itself. Thus, while a sophisticated message bus is being designed and developed at NOAO, concepts for a minimal buy-in message bus are being developed at SAO. Our aim is to try to merge these efforts when ideas and prototypes have stabilized.

A second important part of this project is research into platform-independent graphics and imaging. A considerable effort has been made to study and evaluate Java and Tcl/Tk as possible alternatives to sole reliance on the X Window System (and therefore, reliance on Unix-based computers). We have studied not only the languages themselves, but also a number of image programs implemented with them. Based on this assessment, we have chosen Tcl/Tk as a provisional framework for a platform-independent image widget and we have begun designing this widget using the existing SAOtng/ximtool Gterm-image widget as a model. (However, our design will in principle allow us to switch to Java if this technology matures to a point where it can support the sophisticated functionality we require.)

3 Plans for Next Reporting Period

In the coming year, we will implement several PIE server components, while continuing to support current SAOtng users.

We are planning release 1.8 of SAOtng for spring of 1998. This release will support access to FITS image extensions and FITS binary tables. Image extensions increasingly are being used by the NASA community (*e.g.*, new Hubble Space Telescope data) to maintain related

images in a single file. FITS binary tables are used to maintain discrete lists of events, *e.g.*, for X-ray detectors. We need to support direct imaging of both types of data in SAOtng.

This planned release of SAOtng also will support overlay graphics. For example, we will support the display of RA/Dec grids. We also will support polyline graphics such as contour displays and projections. As usual, other enhancements for SAOtng 1.8 will be made in response to user requests, as resources permit. (For example, we plan to implement a more sophisticated scheme for selecting region of interest markers, in response to a request from a planetary science group at JPL.)

In parallel with work on the current SAOtng, we will proceed with a detailed design and full implementation of a message bus for astronomy. It is anticipated that PVM will provide the basis for this implementation. We also will finish the Distributed Shared Object framework and implement the Distributed Shared Image using the DSO. This work will be incorporated into the NOAO Mosaic Data System as a test-bed. A prototype data capture agent and real-time data display will be developed to exercise various aspects of the message bus and the DSO technology.

This year we also will implement a simpler message bus that emphasizes "minimal buy-in" concepts. As explained earlier, this will be done separately from the main work on message bus implementation in order that the latter work can be guaranteed success; we recognize that hiding complexity from users adds a new level of difficulty in the implementation and we need to ensure that the message bus itself will work properly. Toward the end of the year, we will seek to merge these two implementations. Note, however, that the PIE server itself will be designed to support multiple input mechanisms, and thus could support two message bus schemes. For example, the full message bus could be used for interaction with complex distributed software, while a simpler message bus could support user interaction.

In the coming year, we also will proceed with implementation of a new Tcl/Tk image widget. We will continue current design efforts and will implement a widget that duplicates the functionality of the current Xt-based Gterm-image widget. In addition, we will seek to add support for deep frame buffers and for color models other than the standard PseudoColor model that currently is used by most astronomical image display programs. In particular, we will seek to add support for the 24-bit TrueColor model. This will be of great interest to the Earth science community, where deep TrueColor frame buffers are used to overlay several related data sets simultaneously. This work will be done using X as the underlying graphics technology for the widget, but we will seek to isolate the X calls so that the widget can be ported to other platforms (such as Windows and MacOS).

We also will re-work the SAO R&D software suite to use Tk instead of Xt as the basic window toolkit. This Tk conversion will be a further step toward our goal of migrating away from dependence on the X Window System. We expect that all graphics directives in the SAO R&D suite will use platform-independent Tk, except for the SAOtng image widget itself (which must be written specially for each graphics platform).

Along with recoding our graphics programs, this effort will require a redesign of the build procedures for the R&D package in order to maintain "minimal buy-in" at the installation

phase. If all goes well, a release of the SAO R&D suite that uses this new technology is planned for the end of 1998.

Finally, in the coming year we will research and experiment with plug-in technologies, in preparation for a redesign of the image server itself.